Improvements for the Small Field Exposure Tool （SFET） in Selete

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SFET configuration and history

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SFET objective

・Utilized for research and development of EUVL masks and resist materials.

configuration

item	specification
NA	0.3
Field size	0.2x0.6mm
Magnification	1/5

History

2006

Sep Exposure experiments start in Canon, Utsunomiya

Nov Move-in to Selete

2007

Apr Evaluation start

Nov Alignment tool installation

Illumination replacement (critical→koehler)

2008

Jan Thermal insulator installation

Apr SPF (Spectral Purity Filter) optimization

2009

Jan FFP (Far Field Pattern) monitor installation

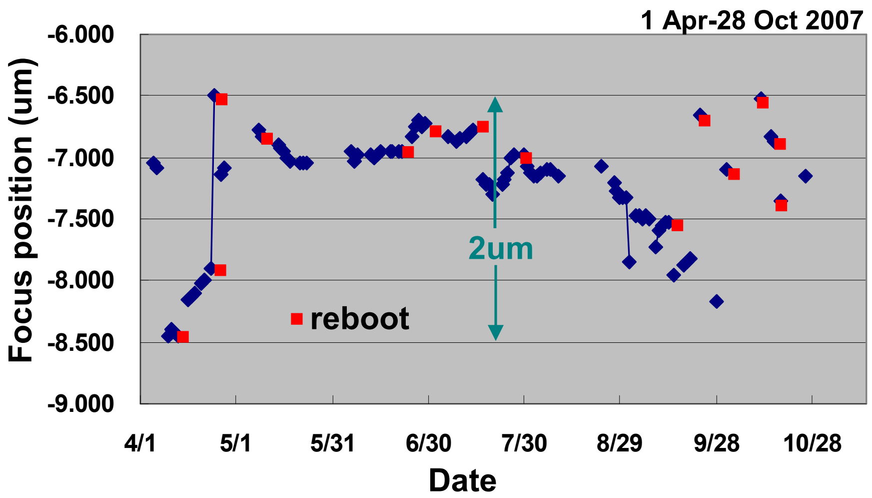
Feb Xe flow rate control application

Jun High-voltage resistance MSC (Magnetic Switching Core) tower installation

Improvements for SFET

item		outline	period
Accuracy	Focus stability	Focus variation improved from 72nm(3sigma) to 30nm	Jan 2008
Light axis alignment	Alignment tool	Utilized for the light axis adjustment on QC	Nov 2007
	FFP monitor	Utilized for the light axis adjustment every collector and DMT replacement	Jan 2009
Throughput	SPF optimization	SPF position and specification change contributed to a high output and gain of 60%	Apr 2008
	Xe flow rate optimization	Xe flow rate optimization contributed to a high output and gain of 30%	Feb 2009
Reliability		High-voltage resistance MSC tower installation	Jun 2009

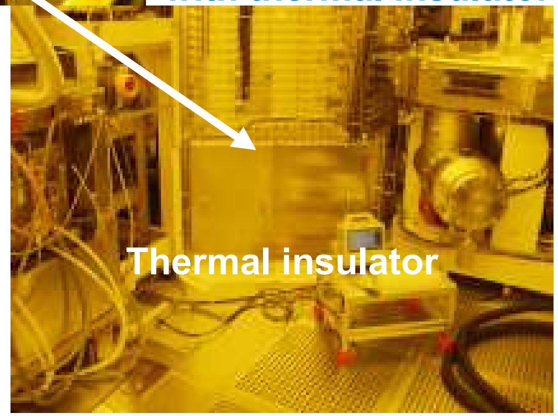
Focus stability

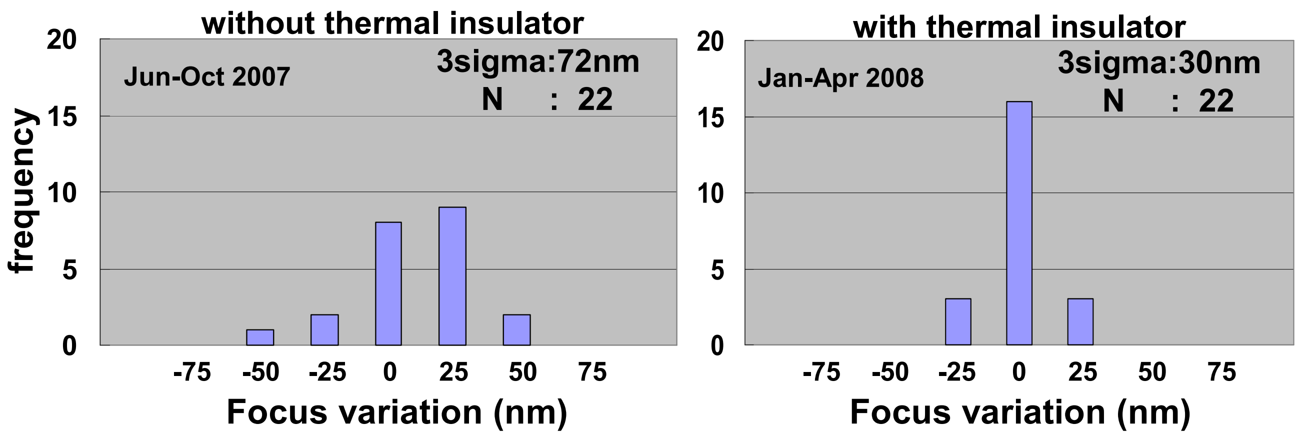


Focus variation in an early stage of SFET evaluation

Wafer stage temperature variation
0.194℃/72hrs without thermal insulator

0.032℃/72hrs
with thermal insulator



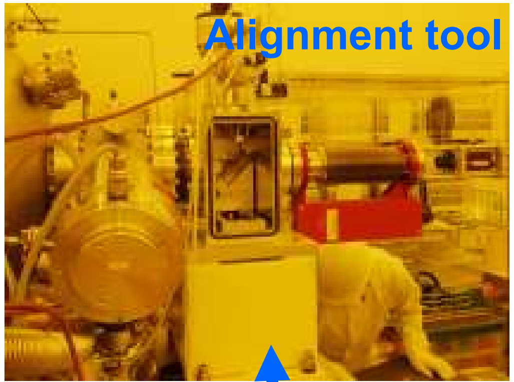


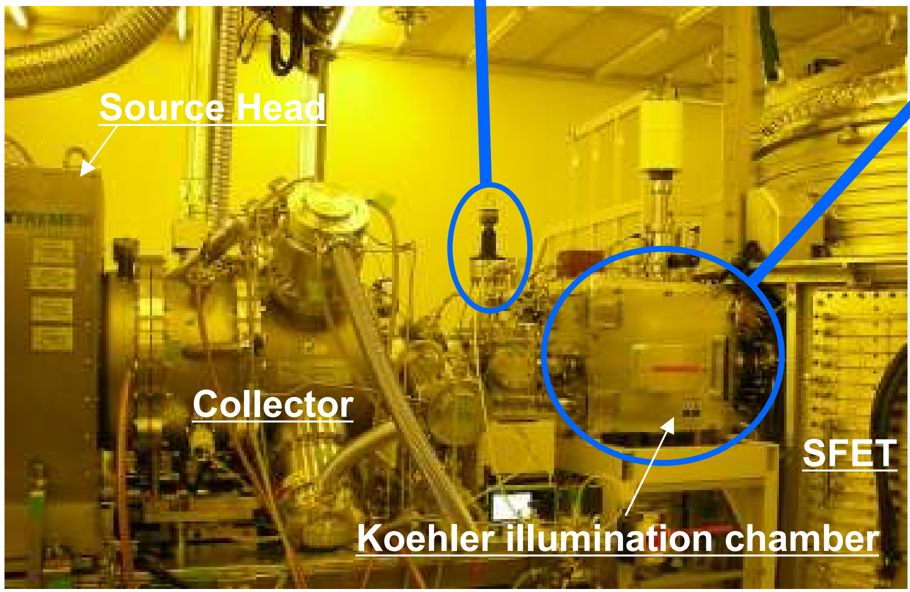
Focus variation histogram

- Focus stability has improved from 72nm to 30nm with wafer stage temperature stabilization though the installation of the thermal insulator.

Alignment of the light axis

・Essential to optimize the axis of the light from the light source to IF point.





Tool	Application	Characteristic
Alignment tool	Daily QC	・Instant measurement (1min/meas.)
FFP monitor	collector, DMT replacement	・Fine observation ・Time-consuming measurement (3hrs/meas.)

Alignment tool

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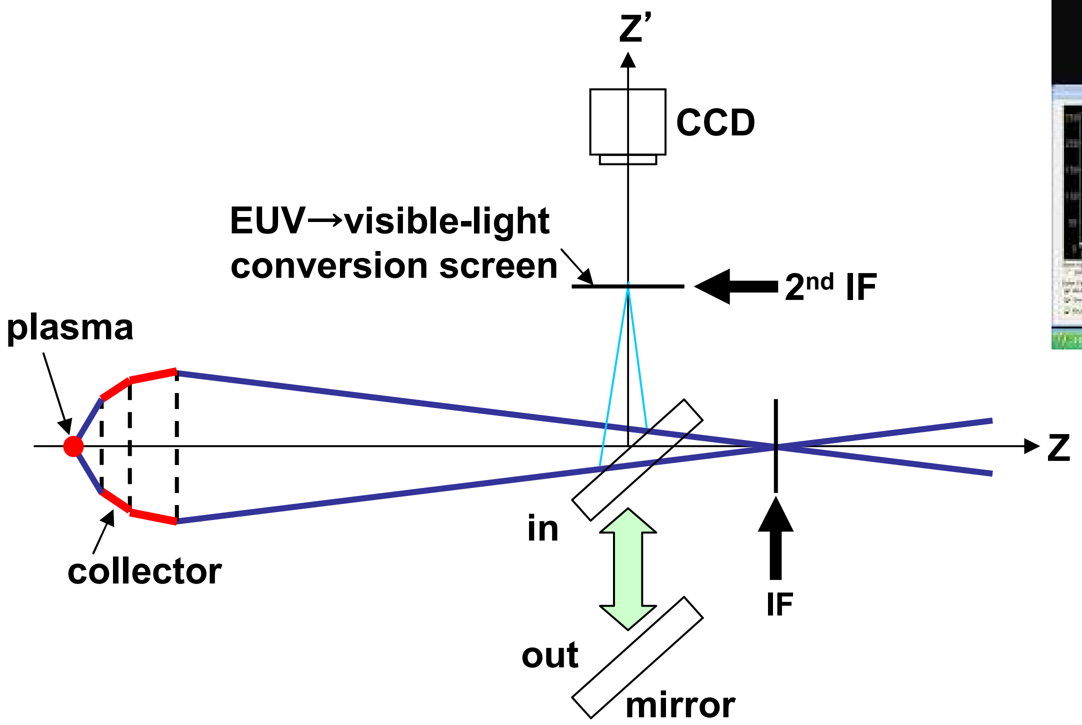
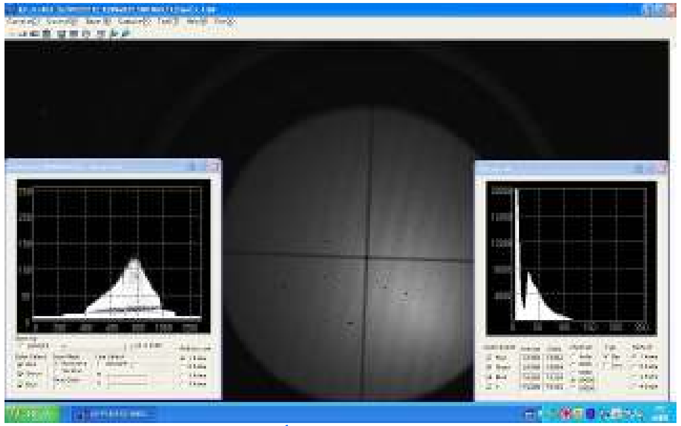
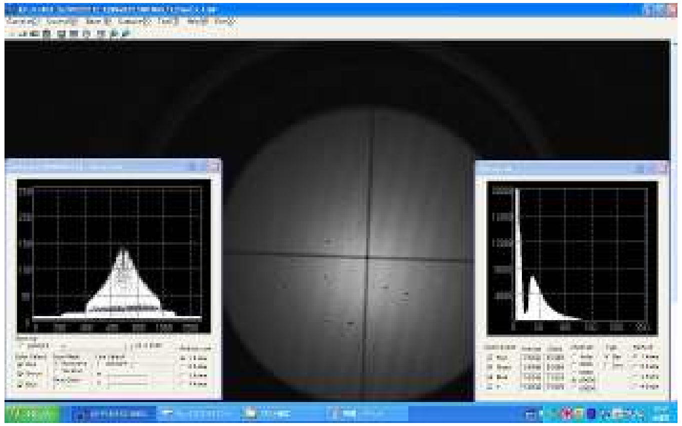
・Possible to observe the image position at the 2nd IF with CCD with the insertion of a movable mirror.



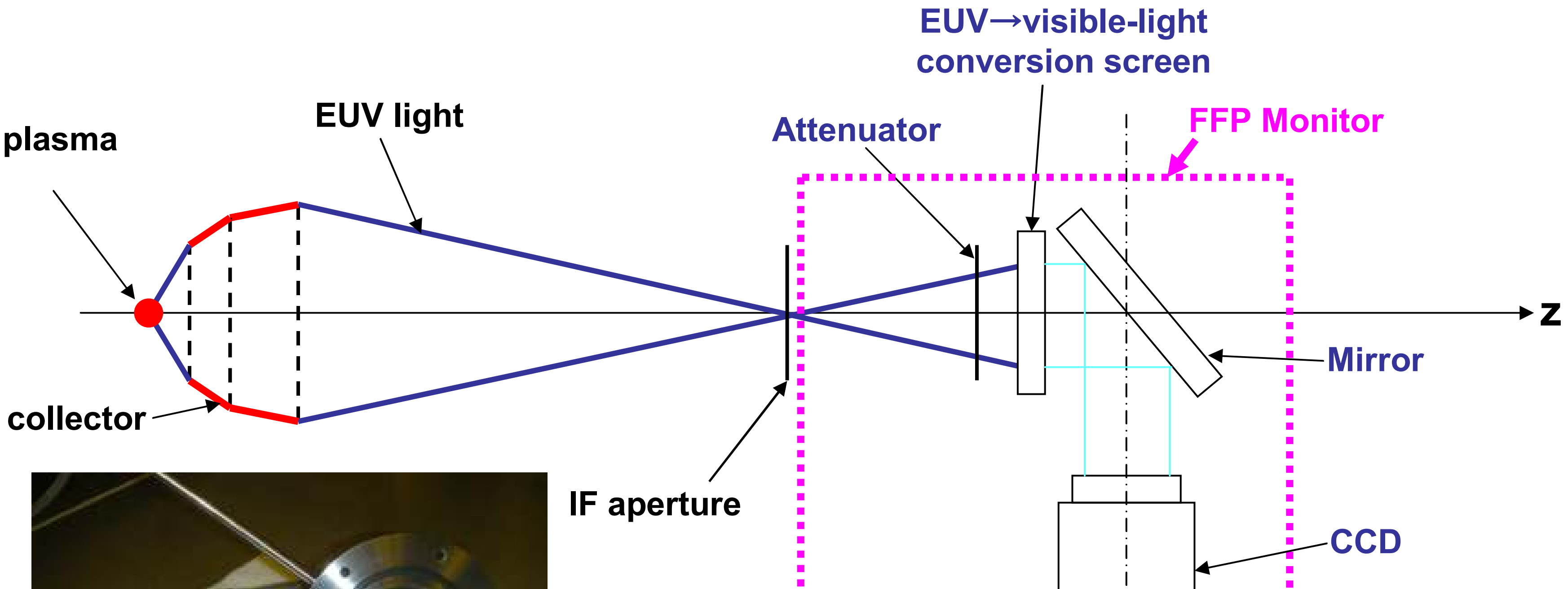


Collector adjustment



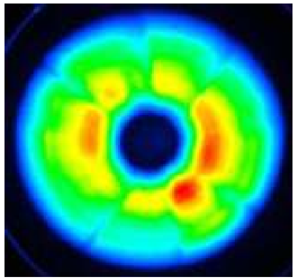
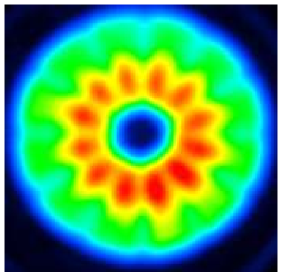
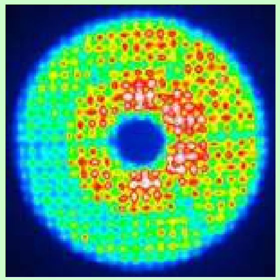
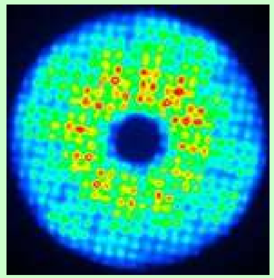
Far Field Pattern Monitor

- Possible to observe Far Field Pattern with CCD.
- Compact design for insertion in koehler illumination chamber.



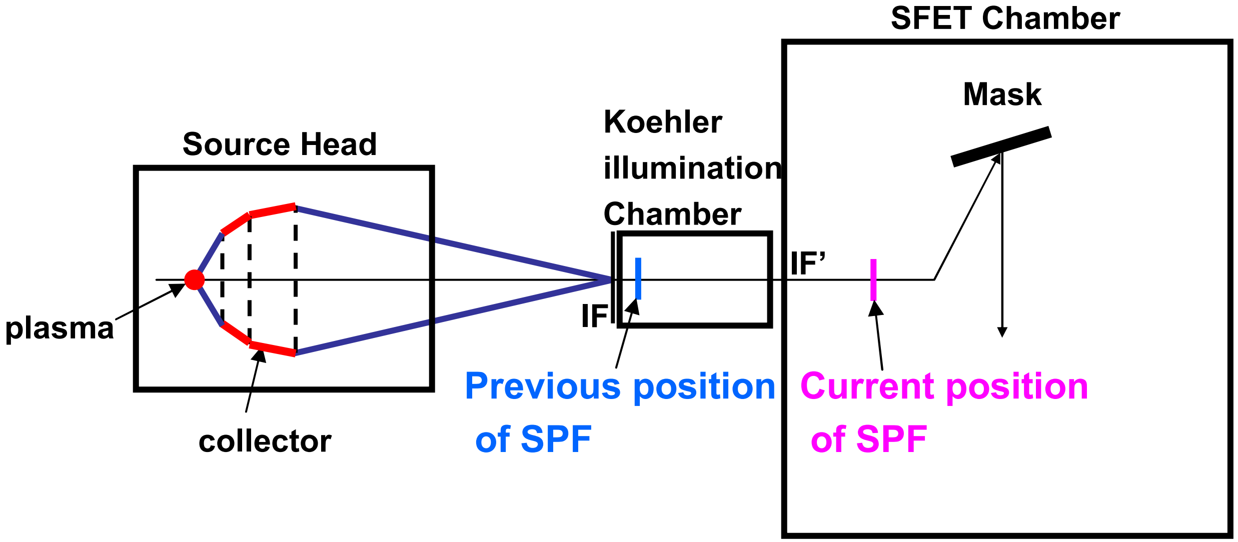
FFP Monitor (detector)

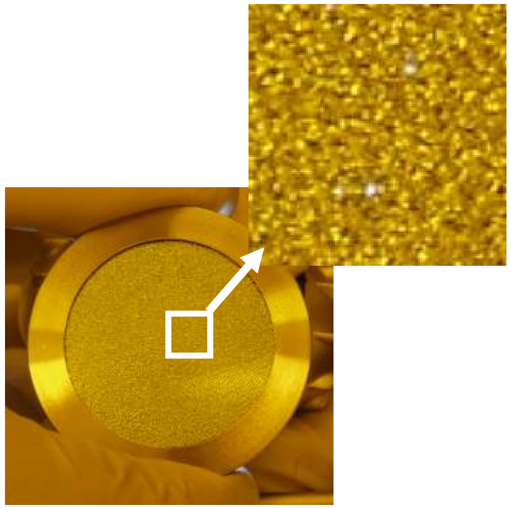
FFP monitor application

Date	Feb-2007	Mar-2008	Aug-2008	Feb-2009	Jun-2009
	Installation	Collector and DMT replacement	DMT replacement	DMT replacement	Collector and DMT replacement
Collector	#1	#2	#2	#3	#4
DMT	#1	#2	#3	#4	#5
Adjustment of light axis	Inconvenient FFP monitor (Need to separate Source Head from SFET)		Alignment tool and pupilgram (exposed wafers)	FFP monitor	
Far Field Pattern	 Φ4mm aperture	 Φ3mm aperture	N/A	 Φ0.5mm aperture	 Φ0.5mm aperture
Approximate time required	>7days	>7days	>10hrs	<3hrs	<3hrs

SPF optimization

・Applicability of thinner SPF while avoiding damage possible by keeping away SPF from plasma.





Damaged SPF

SPF	specification	transmittance	Intensity ratio
Old	Si(50nm)/Zr(150nm)/Si(50nm)	29%	1.0
New	Zr(100nm)	47%	1.6

・SPF position and specification change improved output by 60%.

Xe flow rate optimization

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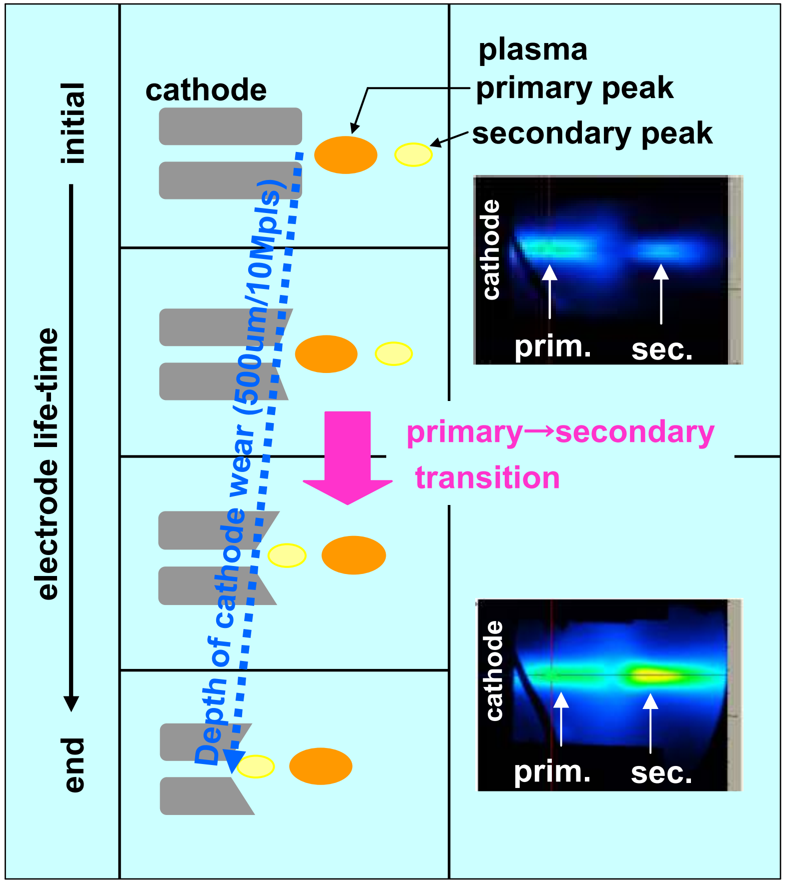
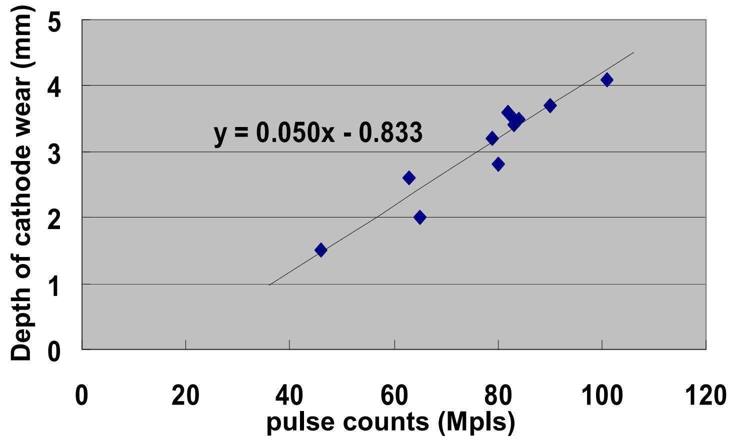
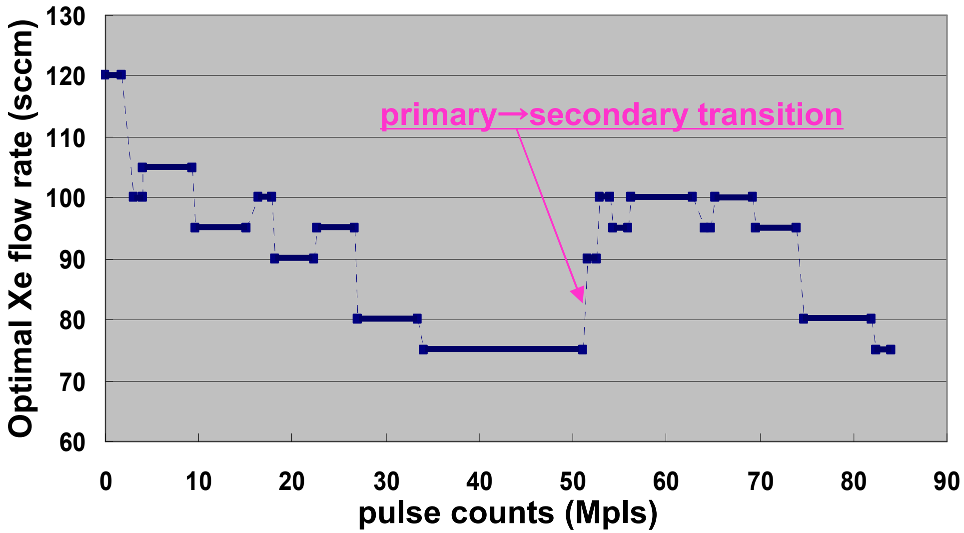


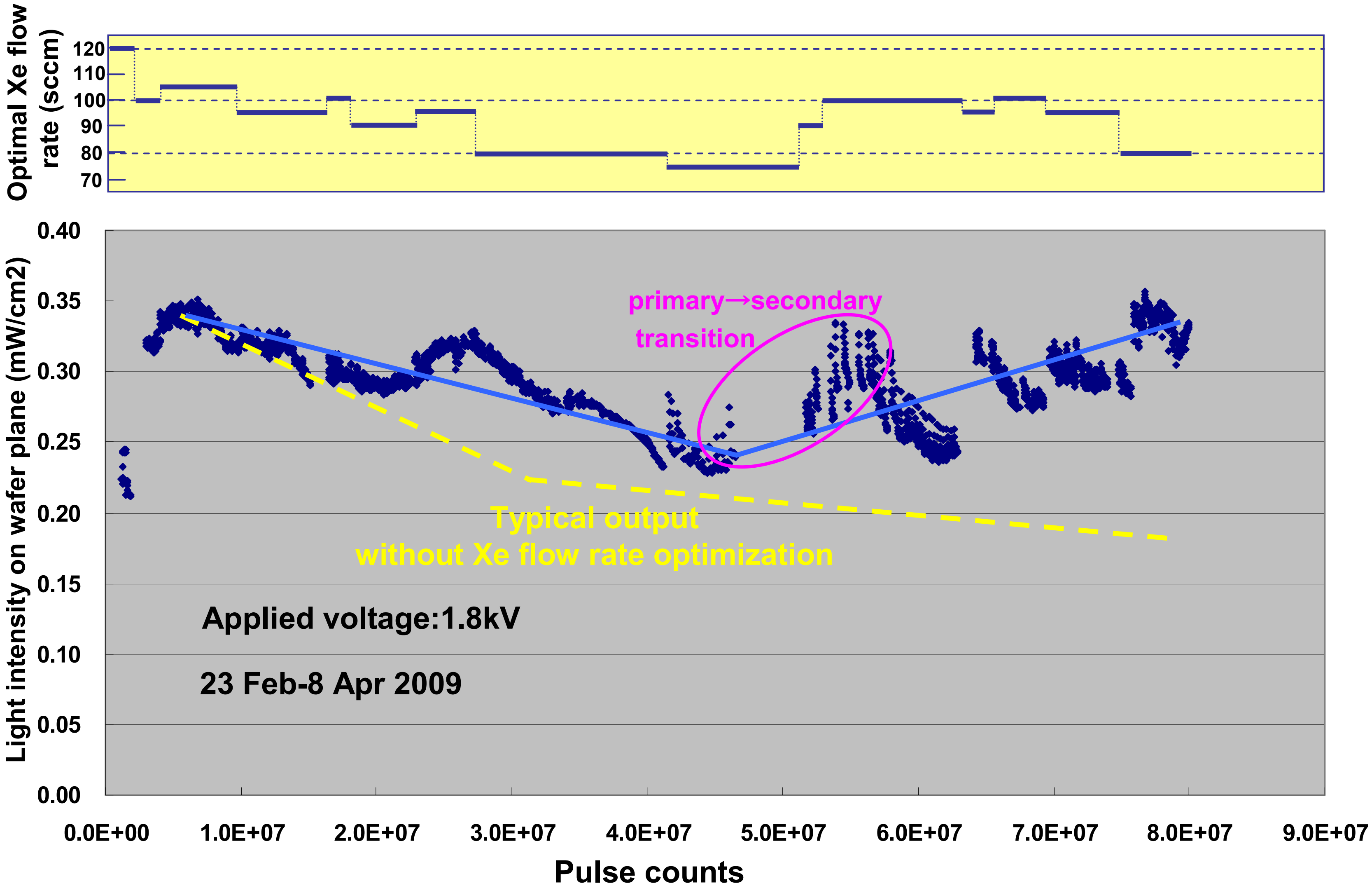
Diagram plasma position during electrode life-time





・Due to electric field and Xe density distribution change, caused by electrode geometry, Xe flow rate optimization is required.

Xe flow rate optimization results



- Xe flow rate optimization contributed to a high output and gain of 30%.

EUV light intensity trend

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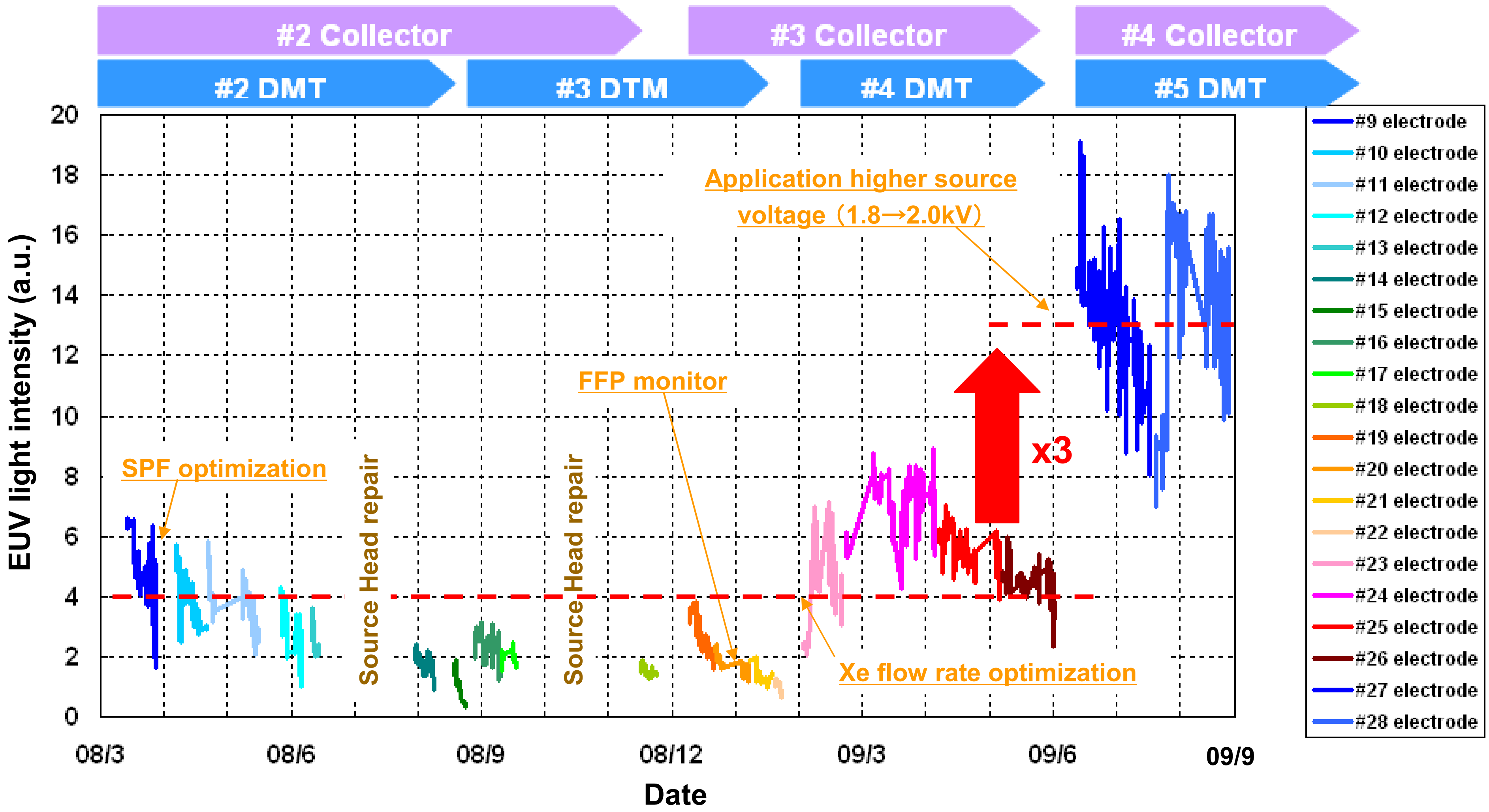

・EUV light intensity has almost tripled in magnitude.

Total number of wafer exposed by SFET in the last 2 years

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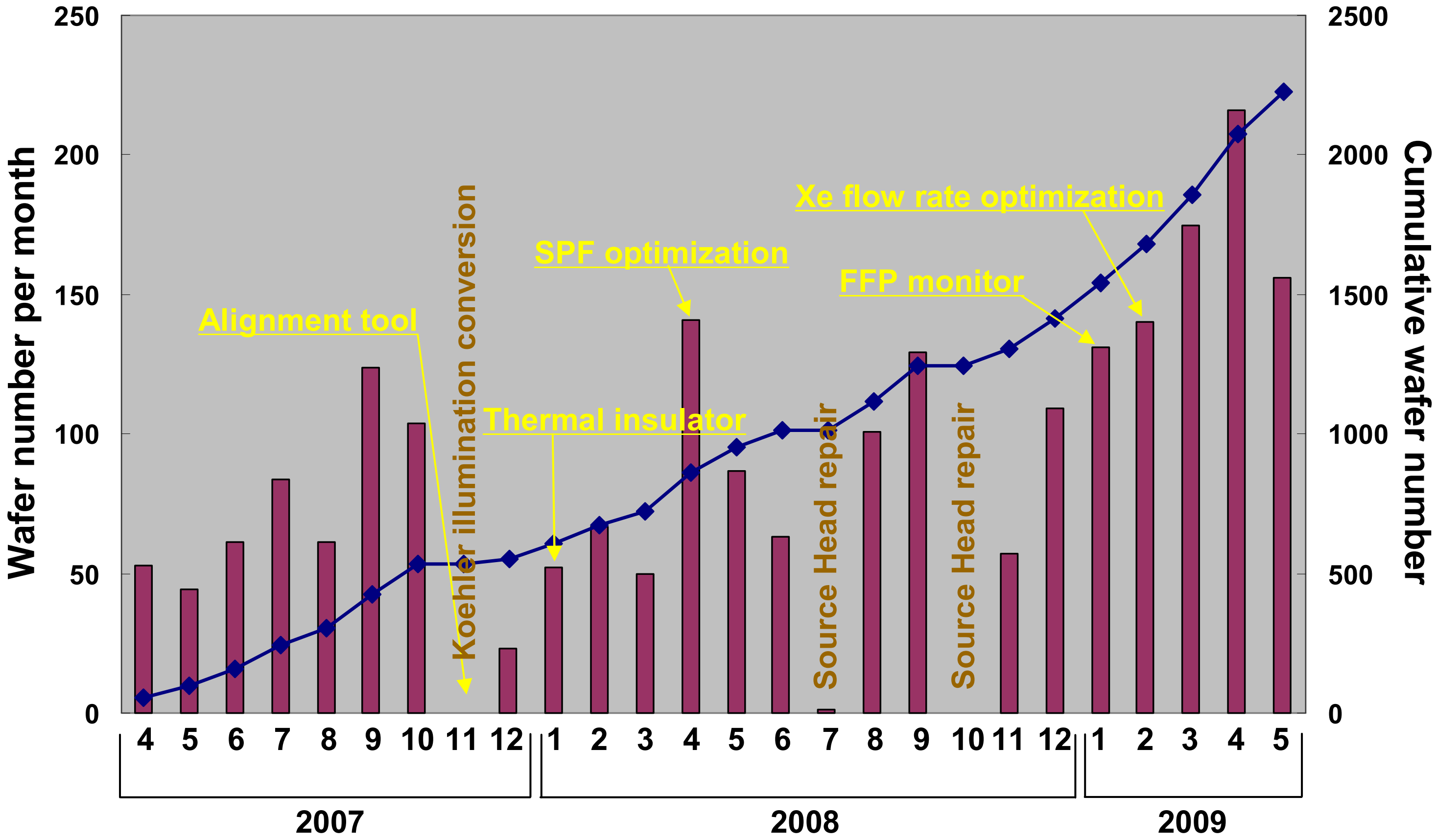

·More than 2,200 wafers exposed.

Summary

■The SFET has been utilized for research and development of EUVL masks and resist materials since it was installed in Selete, 2007, April.

■Various improvements have been made for the SFET in last 2years.

- Focus stabilization

  With thermal insulator, the wafer stage temperature was stabilized within 0.032℃ for 72hrs, contributing to a stability improvement from 72nm (3sigma) to 30nm.

- Alignment of the light axis

  Essential to adjust the optical axis between the light source and IF point to maintain a high output.

  ＊Alignment tool

  Utilized for every daily QC.

  ＊FFP monitor

  Utilized for every collector and DMT replacement.

- Throughput

Summary

∗ SPF position and specification change

Applicability of thinner SPF while avoiding damage possible by keeping away SPF from plasma. The thinner SPF improved output by 60%.

∗ Xe flow rate optimization

Due to electric field and Xe density distribution change, caused by electrode geometry, Xe flow rate optimization is required. Xe flow rate optimization contributed to high output and gain of 30%.

- EUV light intensity has almost tripled in magnitude and the total wafers exposed by the SFET for the last 2 years reached more than 2,200 wafers.

[Future plan]

- Application of higher EUV source voltage (on going, Jun 2009-)
  Plan to increase applied voltage from 1.8kV to 2.0kV to achieve higher output.
- Job reservation function installation
  Automatic and successive processing of multiple wafers of different process conditions possible.

Acknowledgments

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End

Semiconductor Leading Edge Technologies, Inc.